Effects of grazing intensity on forage nutritive value of dominant grass species in Borana rangeland Southern, Ethiopia

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Forage nutritive value analysis is an essential indicator of rangeland status regarding degradation and livestock nutrient demand. This is used to maintain healthy sustainable rangeland that can provide the livestock with sufficient quantity and quality of forage. This study was conducted with the aim of investigating the effects of grazing intensity with a seasonal variation on the nutritive values of dominant grass species in Teltele rangeland. The Grazing intensity was classified as non-grazing, moderately grazing, and the over-grazing site based on estimated potential carrying capacity. Sampling data was collected during both rainy, and dry seasons. The collected forage sample was analyzed for concentrations of crude protein (CP), acid detergent organic fiber (ADF), neutral detergent fiber (NDF), acid detergent lignin (ADL), ash, dry matter digestibility (DMD), potential dry matter intake (DMI), and relative feed/forage value (RFV). The results showed significant ($P < 0.05$) effects of both grazing intensity and season to grazing intensity interactions on all forage nutrient content concentrations across all grass species both within and between treatments. The CP concentrations of all grass species were recorded high at the over-grazing site and low at the non-grazing site and the fiber concentration of all grass species was vis-versa. The RFV also showed significant differences and high value recorded at the over-grazing site and interaction with the rainy season and low at the non-grazing site mainly during the dry seasons. Furthermore, we recommend that moderate grazing should be practiced on the study site to maintain the quality and quantity of forage and to sustainably manage it.

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Abstract

Forage nutritive value analysis is an essential indicator of rangeland status regarding degradation and livestock nutrient demand. This is used to maintain healthy sustainable rangeland that can provide the livestock with sufficient quantity and quality of forage. This study was conducted with the aim of investigating the effects of grazing intensity with a seasonal variation on the nutritive values of dominant grass species in Teltele rangeland. The Grazing intensity was classified as non-grazing, moderately grazing, and the over-grazing site based on estimated potential carrying capacity. Sampling data was collected during both rainy, and dry seasons. The collected forage sample was analyzed for concentrations of crude protein (CP), acid detergent organic fiber (ADF), neutral detergent fiber (NDF), acid detergent lignin (ADL), ash, dry matter digestibility (DMD), potential dry matter intake (DMI), and relative feed/forage value (RFV). The results showed significant ($P < 0.05$) effects of both grazing intensity and season to grazing intensity interactions on all forage nutrient content concentrations across all grass species both within and between treatments. The CP concentrations of all grass species were recorded high at the over-grazing site and low at the non-grazing site and the fiber concentration of all grass species was vis-versa. The RFV also showed significant differences and high value recorded at the over-grazing site and interaction with the rainy season and low at the non-grazing site mainly during the dry seasons. Furthermore, we recommend that moderate grazing should be practiced on the study site to maintain the quality and quantity of forage and to sustainably manage it.

INTRODUCTION

Rangelands are the primary and cheapest source of forage for livestock (Ismail, Fatur, Ahmed, Ahmed & Ahmed, 2014). In most countries including Ethiopia, livestock industry centrally depends on the natural rangeland like Teltele rangeland (Adnew *et al.,* 2018). Livestock that depends on such natural rangeland faced highly fluctuated nutritive value forage grass species even if the rangeland has complicated grass species (Gelayenew *et al*., 2016; Newman *et al.,* 2009; Vendramini, 2010). The nutritional value of the rangeland forages is varying due to influencing factors like grazing intensity, soil type, water availability, maturity/stage of development, plant part (leaf vs. stem), season (rainy vs. dry), environmental effects (moisture and temperature), altitude and management practice (Amiri &Mohamed, 2012; Henkin *et al*., 2011; Jank *et al*., 2014; Kaplan *et al.,* 2014; Adesogan *et al*., 2011). Moreover, evaluating the rangeland forage nutritive value is used to estimate the carrying capacity of the rangeland and also used to assess animal performance (Godari *et al.,* 2013). The livestock selection of grass species for forage depends on the acceptability nature of grass and it is linked with the flavor of forage (like smell, taste, and texture), and its nutritive value (Estell *et al*., 2014). Although, based on the density of acceptable forage species, does not estimate the nutrition quality of forage in the grazing area (Samuels *et al.,* 2015).

The productivity and health of grazing livestock mainly depend on the nutritional quality obtained from the grazing grass species, like proteins, fiber, and mineral elements (Brisibe *et al*., 2009; Massey *et al.,* 2007). Therefore, key aspects to consider when evaluating forages include protein, fiber, and mineral nutrient concentrations (Juárez *et al.,* 2013). In Teltele rangeland, the livestock population becomes highly increased and caused overgrazing. Overgrazing resulted in significant changes in both the productivity and forage nutritional value in the grass species of rangeland, because of yearly round grazing without any resting of grazing site (Selemani *et al*., 2013). If the grazing intensity (GI) increases, there is a decrease of neutral detergent fiber (NDF), acid detergent fiber (ADF), lignin, and an increase of crude protein (CP) and dry matter digestibility (DMD) (Cline *et al*., 2009; Smart *et al.,* 2010). As Derner, (2009) and Njidda, Olatunji & Raji, (2012) indicates that with increased stocking rate or grazing pressure, there is a decline in animal performance. Seasonal changes in forage nutritional value shows a linear decrease in N and CP and linear increase in NDF from rainy to dry season since digestibility become decreased due to high temperature resulted in a decline in the leaf-to-stem ratio (Kirch *et al.,* 2003).

In Teltele rangeland, the local pastoralists select communal grazing areas for their livestock grazing for continuously. However, in communal grazing rangelands, livestock overgrazes the desirable grass species and causing degradation (Asmare *et al.,* 2017). Dynamics of forage nutritive value in communal rangeland areas have become a focusing area for many academicians to address the linkage with livestock grazing intensity with forage nutritive value (Schut *et al*., 2010). Understanding these effects and managing accordingly is crucial for proper grazing systems (Xiajie *et al*., 2018). Thus, understanding the spatial and temporal changes in forage quality in the rangeland is essential for livestock farmers (Wubetie *et al*., 2018). In support of this idea, estimating the effect of GI on forage quality is important to update knowledge for maintaining sustainable grassland management in the Teltele rangeland. But, to date, there is no documented study data about the impact of grazing intensity on forage nutritive value of dominant grass species in the Teltele rangeland, even if there were many studies conducted in arid and semi-arid rangelands around different parts of the world. This becomes one of the major gaps for substantial rangelands management through balancing grazing capacity and maintain livestock performance.

Therefore, rangeland restoration through evaluating the impact of GI on forage nutritive value requires clear measured data using spatial methods comparable across all species within the study site. This study aimed to achieve the following objectives: (1) to evaluate the effect of grazing intensity on the forage nutritive value of dominant grass species, and (2) to compare and contrast the nutritive values of dominant grass species during dry and rainy seasons in relation with grazing intensity. Accordingly, to assess and recommend an appropriate solution for the impact of GI, we asked the following question: How and to what extent the effect of GI in combination with climate (seasonal) variation on grass species productivity and nutritive value in Teltele rangeland? Simply stated, the null hypotheses of this study were: (1) variation of GI across grazing land was not a significant impact on both forage nutritive value and sustainable management of rangeland., and (2) the primary productivity, GI, and livestock productivity were similar both during the rainy season and the dry season.

MATERIALS AND METHODS

Study site

Both the site selection and data collection were done using the same procedures used previously by the same author Fenetahun *et al., (*2020) specifically while conducting the study "dynamics of forage and land cover changes in Teltele district of Borana rangelands, southern Ethiopia: using geospatial and field survey data". The study was conducted in the Teltele semi-arid rangeland in the Borana zone of Southern Ethiopia, by selecting areas that were no-grazed (NG) or had moderated (MG) and overgrazed (OG) as a treatment and based on the calculated carrying capacity of those areas for two consecutive seasons in 2019 (Fig. 1) (Fenetahun *et al.,* 2020). It is located between 04° 56' 23" N latitude and 37° 41' 51"E longitude (Fenetahun *et al.,* 2020; Dalle *et al.*, 2015). The site was selected as previously described in Fenetahun *et al.,* (2020) because it is one of the arid parts of Borana zone and, therefore, the pastoral communities of this region are the most vulnerable to the rangeland degradation as a result of overgrazing. The area is located 666 km south of Addis Ababa, the capital city of Ethiopia (Fenetahun *et al*., 2020). The altitude is about 496-1500 m, the maximum altitude of 2059 m above sea level (Fenetahun *et al*., 2020). Rainfall is bimodal with the main (60%) rainy season occurring between March to May, while the short (27%) rainy season occurs between September to November (Dalle *et al*., 2015; Fenetahun *et al*., 2020) (Fig. 2). The two intervening dry seasons are from June to August and December to February, when forage resources are scarce (Fenetahun *et al.,* 2021; Angassa, 2014). The mean annual rainfall recorded for the past 12 years (2008-2019) was between 450 and 700 mm (NMA, 2019, and Gemedo, 2020), while the mean annual temperature varies from 28 to 33^{0}C with little seasonal variation (Fenetahun *et al*., 2020). The annual potential evapotranspiration of the area is 700-3000 mm (Billi *et al*., 2015). The main soil type in the study area includes 53% sandy, 30% clay, and 17% silt are mainly used to support the growth of grazing grass species (Fenetahun *et al.,* 2020 and 2021; Coppock, 1994; Gemedo, 2020). Based on the relative coverage the rangeland vegetation mainly dominated by encroaching woody species and those that frequently thinned out, include *Senegalia mellifera, Vachellia reficiens, and Vachellia oerfota* (Coppock, 1994; Gemedo *et al.,* 2005; Fenetahun *et al.,* 2020). According to the latest census conducted in 2015, there is a reported population of 70,501 for this woreda, including 36,246 men and 34,255 women; 4,874 (6.91%) of its population are urban dwellers. Cattle, goats, sheep, camel, mule, donkey, and horse are the main species of livestock (Fenetahun *et al*., 2020). Further, according to data reported by the zone livestock office, the estimated total number of herds of each species is 201,148, and the proportion in the herd and densities of each species found in the study district are cattle 92,000 (45.7%), goats 58,139 (28.9%), sheep 17,210 (8.6%), camels 15,305 (7.6%), horses 8000 (4.9%), mules 3,494 (1.7%), and donkeys 7000 (3.5%) of the total livestock population grazed in the study area. Furthermore, for the OG site, all species grazed year-round without rest, as pastoralist migration from one area to another is highly restricted by government policy, which is a major cause of overgrazing and impact on the nutritional value of grass species in the Borana rangelands.

Experimental design and Sample collection

Data were collected using the same procedures described by Fenetahun *et al*., (2020) the same authors at the same study site. We selected a site with three treatments: a non-grazing (NG) (as a control) and a grazing site both MG and OG sites (used to see the effect of grazing intensity) based on grazing intensity gradient (Fenetahun *et al*., 2021). Inside the NG site, livestock had been abandoned, and to compare the variations forage nutritive value and to evaluate the impact of GI. And also, GI was divided into NG, MG, and OG based on the current stocking rate and carrying capacity potential (Fenetahun *et al.,* 2020 and 2021). The livestock species found in all grazing treatments are the same and the only difference is density and GI. Once the amount of forage yield and utilization rate was determined, the carrying capacity was calculated. The information can be used in two alternative ways: (a) to determine stocking rate or the number of heads a system can carry the total livestock unit (TLU) (TLU ha^{-1} $year^{-1}$) or (b) to determine how many areas a specific herd can graze in the system (ha TLU^{-1} $year^{-1}$) (FAO, 1988). Similar to CC calculation, we applied 30% consumable rate on the potential yield and calculated the stocking rate using the following formula:

$$\text{Stocking rate for the year } (\text{TLUha}^{-1}\ \text{year}^{-1}) = \text{TLU} / \text{total grazing area} \quad (1)$$

The treatment sites of sample collection involved at a stoking rate of NG (~ 0 TLU $ha^{-1}Y^{-1}$), MG (2 TLU ha^{-1} Y^{-1}), and OG (4 TLUha^{-1} Y^{-1} and above) based on the current forage biomass yield and carrying-capacity of rangeland calculated by Fenetahun *et al.,* (2020) and physical field observation. The treatments with different GI were selected and investigated within 2 km interval (Fenetahun *et al*., 2021). The selected rangeland sampling areas of these three GI sites were 100 ha for each (in total one NG + one MG + one OG sites = 300 ha) (Fenetahun *et al.,* 2021). The sites were selected from a homogeneous area and had similar geographical conditions like slope, elevation, and soil types (Fenetahun *et al.,* 2021). The grazing treatments and sample collection were implemented both during the dry season (December 2018 to February 2019) and the rainy season (March to May 2019) at the time where grass species were identified easily and peak biomass was recorded in order to evaluate the interactional effect of seasonal variation with GI, with three replications (Fenetahun *et al*., 2021). Then, after establishing a 5km transects both in the NG and grazing rangeland sites, we established five 50X50m plots at 500m interval, total of

15 plots (three treatments with five plots each) were used. Then, in each plot, three 5 X 5 m subplots were randomly assigned as pseudo-replicates out of a total of 45 subplots in grazing and non-grazing treatments (Fenetahun *et al*., 2020 and 2021). Finally, five 1 X 1 m quadrats in each subplot, with a total of 225 quadrats per season (450 quadrats in two sampling season) were assigned by randomly casting them back side to minimize any bias resulting from selective placement in each subplot for the collection of samples of grass species over two consecutive seasons (Fig.1) (Fenetahun *et al*., 2020 and 2021). The total sampling of (5 plots X 3 sub-plots X 5 quadrats X 2 seasons X 3 replications = 450 for each treatment site) was conducted (Fenetahun *et al*., 2020 and 2021). Moreover, the sample collection techniques and treatment site are the same during the dry and rainy season (Fenetahun *et al*., 2020 and 2021). In each sampling unit, we recorded the dominant grass species and abundance for each grass species (Fenetahun *et al*., 2020 and 2021). And all the above ground grass samples were harvested by using a cutter and each grass species was collected separately in a paper bag (Fenetahun *et al*., 2020 and 2021). The fresh weight of the collected grass samples was measured in the field with a scale (Fenetahun *et al*., 2020 and 2021). Then the samples were oven-dried for 48 h at 55^{o}C to determine the biomass. The sub samples were used to calculate the dry weight of forage mass and estimate forage nutritive value described below (Fenetahun *et al*., 2020 and 2021). The dried samples were measured and grounded to pass it a 1mm screen for further analysis at Bahir Dar University, Ethiopia college of agricultural laboratory. The forage evaluated consisted of five dominant grass species (*Chloris roxburghiana*, *Cenchrus ciliaris*, *Chrysopogon aucheri*, *Aristida kenyensis* and *Digitaria milanjiana*) were selected and sampled based on the relative abundances (≥ 40%) and pastoralists' experiences of preferences on each grass species (Habtamu *et al.,* 2013). Identification of the grass species was done in the field using identification keys, plates, Flora of Ethiopia books, and the Addis Ababa University national herbarium (Dalle *et al*., 2015). The specific assessment for a detailed acceptability value of dominant grass species and soil physicochemical properties was given by a study carried out on the same site and by the same author (Yeneayehu *et al*., 2020).

Forage nutritive value analysis

Forage samples were analyzed for multiple quality factors on a dry mass basis, with a crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), Ash, dry matter digestibility (DMD), potential dry matter intake (DMI), and relative feed/forage value (RFV) following standard procedures described under (Table 1). The calculated result of CP, NDF, ADF, and ADL was expressed using g/kg as unit and Ash, DMD, RFV and DMI were expressed as parentage (%). Based on the obtained result of NDF, ADF, DMD, and DMI the forage nutritive quality of grass species can be estimated and ranked by using the following formula (Fazel *et al*., 2012). DMI is an estimate of the relative amount of forage an animal will eat when only forage is fed. DMI is calculated as a percent (Undersander *et al.,* 1993).

$$\%DMI = 120 / \%NDF \qquad (2)$$

$$RFV = \frac{DMD (\%) \times DMI (\%)}{1.29} \qquad (3)$$

RFV= relative forage value of forage species predicted from NDF and ADF.

Statistical analysis

Forage nutritive value data were analyzed using SPSS Version 22 with grazing treatment and season as well as their interactions as fixed factors, and plot considered a random effect. Plot was treated as a repeated measure variable. There were 450 sample observations (5 plots X 3 sub-plots X 5 quadrats X 2 seasons X 3 replications) in each GI site for each forage variable (CP, ADF, ADL, DMD, DMI, NDF). Repeated measures analyses for forage nutritive values were performed using a mixed model (Proc Mixed), including GI (NG, MG and OG), season (dry and wet) as a repeated effect, and their interactions. A two-way analysis of variance (ANOVAs) followed by a Duncan's multiple range test were performed to test for significant differences ($P < 0.05$) between controls (NG), MG, and OG treatment within and between each season. A simple linear regression analyses were conducted to examine the relationship between GI and various variables (forage nutritive value response ratio to grazing in each season). A principal component analysis (PCA) was used to examine the relationship of forage nutritive value of the species based on the experimental results.

RESULTS

Effects of grazing intensity on forage nutritive value

The relative abundance of the selected dominant grass species across all grazing intensity and season were presented in (Fig. 3). *C. roxburghiana*, *C. ciliaris* and *C. aucheri* had > 60%, A. *kenyensis* ≥ 50%, and *D. milanjiana* had ≥ 40% abundance both during the rainy and dry season. *C. aucheri* is the most abundant grass species in Teltele rangeland followed by *C. ciliaris* and *C. roxburghiana*. The effect of GI on forage nutritive value showed significant difference ($P < 0.05$)

in terms of CP, ADF, NDF, ADL, ash, and RFV contents both within and between species (Table 2). The concentration of CP and ash contents was increased when rate of GI increased, but the concentration of ADF, NDF, and ADL was decreased when the rate of GI increased across all grass species. The effect of GI on the forage nutritive value was describing using a linear regression analysis (Fig. 4) using the dominant grass species.

According to the result showed from regression analysis, the RFV of forage by an animal showed a significant difference ($P > 0.05$) across each GI. It shows decreasing pattern if the concentration of ADF, NDF, and ADL value was increasing, but the RFV of forage showed an increasing pattern when the concentration of CP and ash value was increasing (Fig. 4). The RFV values used to estimate the forage quality and the higher RFV value means the most forage quality. *C. roxburghiana*, A. *kenyensis,* and *C. aucheri* are grass species that showed high forage quality based on our data respectively.

In the NG area, the concentration of CP for all grass species showed below the minimum requirement of both for beef cattle (7%) with the exception of C. *ciliar (7.7%)* and for small ruminants (9%) (Gemedo, 2020; Habtamu *et al.,* 2013). Across in all GI, the concentration of CP for *C. roxburghiana, A. kenyensis* and *D. milanjiana* were below the minimum requirements for the most grazing animals. This is due to at the NG area. The grass maturity was increased and results in less leaf to stem ratio, which causes for increasing of ADF, NDF, and ADL and decreasing of CP. And at the NG area, the forage quality decreases as compared with both the MG and the OG. This is because of decreasing digestibility and protein content with increasing maturation.

On the other hand, with increasing of GI, the rate of new growth declines, and the consumption of less desirable material such as the remaining part of mature forage part from the previous growing season and become causes for the decreasing of CP concentration. The concentration of ADF, NDF, and ADL was recorded high for *D. milanjiana* followed by *C. ciliary* and low for *C. roxburghiana* followed by *A. kenyensis* and the concentration was showed a decreasing pattern across from the NG to the OG site and showed significant difference ($P < 0.05$) both within and between species and GI. High ash content was recorded for *C. ciliary* and low for *C. roxburghiana* and showed a significant ($P < 0.05$) variation both within and between species across GI and increased at the OG site followed by the MG and the NG site respectively.

The interaction effects of grazing and season on forage nutritive value

The nutritional composition of the forage grasses was significantly ($p < 0.05$) different among species and within species due to the interactive effects of seasons and GI rates (Table 3). Therefore, the grazing season not only affects the biomass production of rangeland but also the nutritive value of existing forage grass species on the grazing site. The result indicates that the concentrations of CP, ash, DMD, and DMI content of forage nutritive value was increasing during the rainy season compared with the dry season. The highest values of CP, ash, DMD, and DMI content were recorded at the OG site during the rainy season, whereas, the lowest values were recorded at the NG site during dry season across all grass species.

The CP content in the dry season varied from 1.3% (*A. kenyensis*) to 11.4% (*C. ciliari*) and increased from 6.9% (*A. kenyensis*) to 18.9% (*C. ciliari*) during the rainy season. The ash content varied from 8.1% (*C. roxburghiana)* to 14.8% (*C. ciliari*) during the dry season and increased from 13.5% (*C. aucheri*) to 21.9% (*D. milanjiana*) during the rainy season. The fiber constituents (i.e., ADF, NDF, and ADL) of the forage grass species shows an increasing value during the dry season compared with the rainy season. The highest values of ADF, NDF, and ADL were recorded at the NG site during the dry season, whereas, the lowest values were recorded at the OG site during the rainy season (Table 3). The ranges of ADF, ADF, and ADL content varied from 29.5% (*C. roxburghiana*) to 47.1% (*D. milanjiana*); 37.1% (*A. kenyensis*) to 60% (*D. milanjiana*) and 13.1% (*A. kenyensis*) to 33.7% (*D. milanjiana*) during the rainy season respectively and increased from 38.7% (*C. roxburghiana*) to 59.9% (*D. milanjiana*); 59.3% (*C. roxburghiana*) to 88.5% (C. ciliary) and 26.6% (*A. kenyensis*) to 53.1% (*C. ciliary*) during the dry season respectively. This interaction effect also impacts on the RFV of forage and increased during the rainy season as compared with the dry season. The highest RFV was observed during the rainy season across all GI, especially at the OG site followed by the MG and the NG respectively, and the lowest RFV was recorded during the dry season mainly at the NG site followed by the MG and the OG respectively. *A. kenyensis, C. aucheri* and *C. roxburghiana* are grass species that showed more forage quality ranked from 1 to 3 respectively based on our data.

Based on RFV data those the most ranked forage quality grass species had high CP and ash contents and low fiber components and this indicates that high forage quality is generally related to high CP and low fiber contents of the forage. From this, we can understand that RFV has a direct relationship with forage CP and ash contents and inversely relationship with forage fiber components. The forage of all grass species showed significantly ($P < 0.05$) higher CP, DMD, DMI, and RFV contents and lower ADF, NDF, and ADL contents in the rainy season compared with the dry season. And this seasonal variation in rangeland area is caused for maturity and age difference of forage grass species and resulted variation in nutritional composition of forage grass species within the same grazing site.

Evaluate relationship of nutritional contents of grasses using forage quality index

Using Principal Component Analysis (PCA) the relationship of nutritional contents related to different effecting factors was evaluated. The correlation matrix of forage nutritional contents related to the impact of the seasonal variation in combination with GI and GI independent with seasonal variation was analyzed and explained (Table 4 and 5) respectively. The plotted eigenvalues were obtained from the correlation matrix and variation also calculated and explained by the components (Fig. 5).

As we have seen from table 4 and 5, there was a strong negative correlation of CP and ash contents with fibers (ADF, NDF, and ADL) were observed in all grass species at different grazing season and GI rate and also during their interaction effect. RFV showed a strong negative correlation with ADF during the dry season grazing period and at the NG site. Components loadings with varimax rotation, as well as the eigenvalues showed us there were only two components with eigenvalues higher than one (Fig. 5A) and had 87.067% of the total variance (Table 6). The first component contained 60.564% of the total variance of forage nutrient contents (CP, ash, DMD, DMI, and RFV) and component two contained 25.503% of the total variance of forage nutrient contents (ADL, NDF, and ADL) (Fig. 5B). There was a positive correlation between CP, DMD, DMI, and RFV, and also between ADF, ADF, and ADL of forage nutrient contents. On the other hand, there was a negative correlation between fiber contents (ADF, NDF, and ADL) with CP, ash, DMD, DMI, and RFV were observed (Fig. 5B).

DISCUSSION

In general, our result indicated that the forage nutritive value of all those dominant grass species was increased when GI rate increased and this correspond to those of previous studies (Fanselow *et al.,* 2011; Haiyan *et al*., 2016; Schiborra *et al*., 2009), conducted in a different part of the worlds arid and semi-arid rangelands. This rapid increasing of GI leads to grazing livestock used young regrowth protein-rich grasses (Gete & Gemedo, 2019; Mysterud *et al*., 2011). As a result, the maturation period of forage grass species become decrease, and the fiber contents (ADF, NDF, and ADL) of forage reduced, whereas the CP content becomes increase when GI becomes increased (Yuan & Hou, 2015) and this is directly in agreement with our data recorded in the current study.

The forage maturity is inversely related to CP content and directly related to fibers component content. The amount of CP content within forage used as an indicator of forage nutritive value, means that, best forage quality associated with high CP and low fiber content (Miao *et al*., 2015; Zhai *et al.,* 2018). Typically, high CP content is inversely correlated to fiber content (Zhai *et al.,* 2018). Based on the linear regression analysis data the highest CP content value across all grass species was recorded at the OG and the lowest value at the NG rangeland site. The highest fiber content value across all grass species was recorded at the NG and the lowest at the OG rangeland of the study site. Similar results were reported by Wang *et al*., (2011) a study conducted in Inner Mongolia, and also by Miao *et al.,* (2015), a study conducted on the north-east edge of Qinghai-Tibetan Plateau.

Furthermore, our result was consistent with several studies conducted both at the national and international level in arid and semi-arid rangeland. For example, it was indicated that forage with high nutritive value observed at the site where GI was high (Gemedo, 2020; Habtamu *et al.,* 2013; Zhang *et al*., 2015) and they concluded that forage nutritive value was enhanced by GI. In Teltele rangeland forage nutrient content showed a significant difference ($p < 0.05$) across all grass species related to GI variation. And also, the grass species showed a higher amount of DMD, DMI, and FRV values when the GI becomes increased and DMI is considered as a positive indicator of forage quality (Arzani *et al*., 2006).

Compared with the species nutritive value, a higher nutritive response with GI was observed for *C. roxburghiana* and *A. kenyensis.* This might be because of the fact that grazing animals select the species for more acceptable at any point in time and make it less matured and fast regrowth rate (Selemani *et al.,* 2013; Wan *et al.,* 2011). From this result, we can understand that rangeland management intensity highly affects the forage nutritive value, and grass species that existed in the grazing site have different coping mechanisms to grazing including grazing tolerance (Gamoun, 2014; Ren *et al*., 2016).

During conducting our sample data, the weather condition of the study site was in a normal situation (there was no special climate change like drought or flooding has occurred). Our result showed the forage nutritive value was higher during Rs than Ds and highly inconsistent with previous studies conducted by Haiyan *et al.,* (2016); Müller *et al*., (2014). In arid and semi-arid rangeland areas of Ethiopia, reported that seasonal variation has a significant influence on the nutritional quality of key forage species (Hussain & Mufakhirah, 2009; Teka *et al*., 2012). and our results highly in line with the data reported by the above authors.

In Teltele rangeland scarcity of water is the major limiting factor for grass species growth and more precipitation available in the rainy season and this increase soil water availability and species composition. The concentration of CP was high during Rs because the rate of mineralization and nitrogen assimilation of grass species became high during Rs (Fig. 6). During the Ds, there is a scarcity of precipitation and caused a slow regrowth rate, and maturated forage was high and resulted in high fiber and low CP concentration (Adogla *et al*., 2014; Gete & Gemedo, 2019). Compared to the interaction effect of the season with GI, the highest forage nutritive value was recorded at Rs X OG (over-grazing site during the rainy season), whereas the lowest value was recorded at Ds X NG (non-grazing site during the dry season) across all grass species. And *C. roxburghiana* and *A. kenyensis* are the grass species which gave higher forage nutritive value both during Rs and Ds across all GI site.

In our study site, grazing reduced the abundance of mature forage grass and speedup the new regrowth grass species and this leads to less resistance to drought and sensitivity to water loss that causes a significant variation of nutritive value. Still, there is a limitation of data on forage quality during the early growth period since the major impact on CP occurred during early growth grazing time (Rawnsley *et al*., 2002; Sollenberger, 2007). Therefore, rangeland management practice and pastoralists should consider different grazing seasons in order to meet the required amount and quality forage for their livestock.

In general, our data indicated that the rangeland grass species had shown significant variation on the nutritive values from each other and also between GI and seasonal variation. Our data were highly supported by the studies conducted in arid and semi-arid rangelands around the globe revealed the complex impact of both GI and seasonal variation on the forage nutritive value: including Schönbach, Wan & Gierus, (2012) in Inner Mongolia, Zhang *et al.,* (2015) in Qilian Mountains, Islam, Razzaq & Shamim, (2018) in Pakistan and Mountousis, Papanikolaou & Stanogias, (2008) in South Europe.

Our result indicates that the forage quality of the dominant grass species studied under this study shows a significant ($P < 0.05$) difference. From the recorded dominant grass species *C. roxburghiana* and *D. milanjiana* had the highest and lowest forage quality, respectively across GI.

We found that there was a negative correlation between forage CP and RFV with fiber (ADF, NDF, and ADL) content and a positive correlation between CP, DMD, DMI, and RFV for all species across all GI and season, and our data was in line with the data reported by Lin *et al*., (2011). Such type of finding in agreement with the data reported that high Nitrogen (N) forage content direct linkage to good nutritional quality (Cao *et al*., 2011). This negative relationship between N (CP) and the fiber content of forage is a major indicator of rangeland forage grass species regrowth rate and maturity (Haiyan *et al.,* 2016). Further, the linkage between forage nutritive value indexes highly affected by both GI and seasonal variation.

Our project result has great implications and used as a reference for sustainable management of arid and semi-arid rangelands of Teltele and others in Ethiopia and other parts of the world that are in a similar situation. Since the forage nutritive value fluctuate due to GI and seasonal impact, this research used to provide information for pastoralists to make appropriate preparation for the DS and when over-degradation happens through collecting and providing different supplementary feeds that used for better livestock management and productivity.

The current ongoing grazing intensity and irregular seasonal change may cause rapid rangeland degradation and results in a shortage of forage for grazing livestock. This followed both social, economic, and political instability in the study site and in the country in general. As a result, this finding has a great role in providing information and used to minimize the risk of both rangeland degradation and the cost of living for both human and livestock species. Contrary to our second hypothesis, GI and seasonal variation showed a significant impact on the forage nutritive value of the dominant grass species on our study site. The nutritive value of the grass species in Teltele rangeland is more responsive to grazing disturbance. This indicates that assessment of GI in terms of forage nutritive value is highly important and scientifically recommended for sustainable rangeland management and our first hypothesis is approved.

CONCLUSION

The OG site maintained relatively better CP and less fiber content in all grass species compared with other GI sites. Seasonal variation is also one of the most determinant factors on forage nutritive value and better CP and less fiber was recorded during the rainy season than the dry season and vis-versa. Besides forage nutritive value, both GI and season significantly influenced the availability and amount of forage species for grazing. And the shortage of forage at high grazing intensities resulted in reduced livestock carrying capacity of rangeland. At the same time, the exclusion of rangeland from livestock grazing does not necessarily improve the forage quality, due to the high CP and lowest fiber concentrations was linked with the rate of GI. In the Teltele rangelands, the abundance of desirable grass species was very few, even in areas where grazing was restricted. This indicated that urgent action is needed to restore these rangelands to a state where dominant species are more prevalent. Therefore, in order to balance both forage availability and quality based on the demand for grazing livestock, the implementation of sustainable rangeland management strategies like rotational grazing and maintain grazing intensity on the moderate level is important and recommended for forage producers and pastoralists.

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Figure 1

Location map of the study area and sampling plot layout.

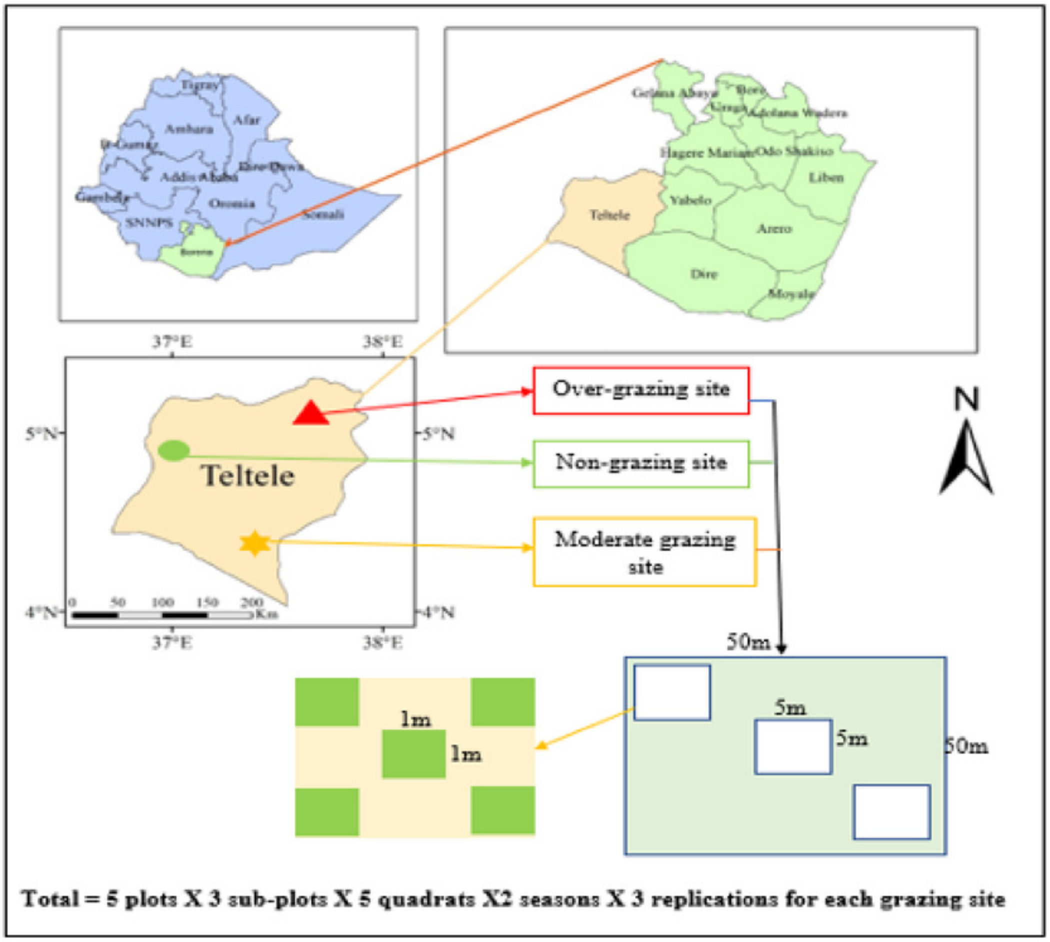
Tigray
Afar
Amhara
Addis Ababa
Dire Dawa
Oromia
Gambela
SNNPS
Somali
Borena
Gelana Abaya
Bore
Uraga
Adolana Wadera
Hagere Mariam
Odo Shakiso
Liben
Yabelo
Teltele
Arero
Dire
Moyale
37°E
38°E
5°N
4°N
0 50 100 150 200 Km
Teltele
Over-grazing site
Non-grazing site
Moderate grazing site
N
50m
5m
5m
50m
1m
1m
Total = 5 plots X 3 sub-plots X 5 quadrats X2 seasons X 3 replications for each grazing site

Figure 2

Mean annual rainfall (RF) and temperature (Temp) from 2008- 2019 in the Teltele rangeland site.

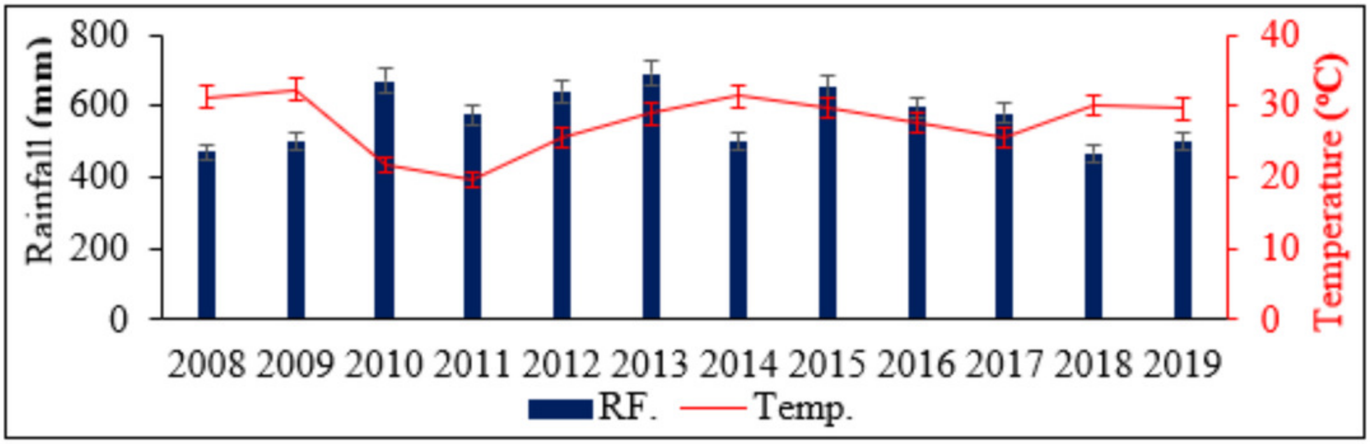

Figure 3

Relative abundance of dominant grass species in the Teltele rangeland.

Rs = rainy season, **Ds** = dry season.

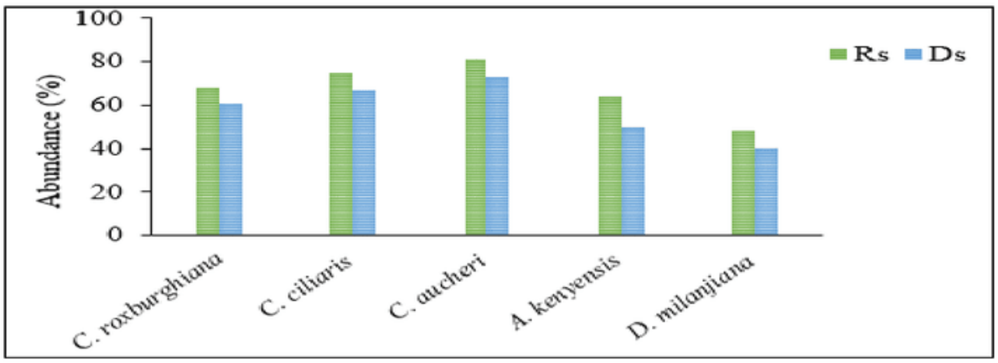

Figure 4

Relationship between stocking rate (SR) and forage nutritive values of each grass species.

A = *C. roxburghiana*, **B**= *C. ciliary*, **C** = *C. aucheri*, **D** = *A. kenyensis* and **E** = *D. milanjiana.*

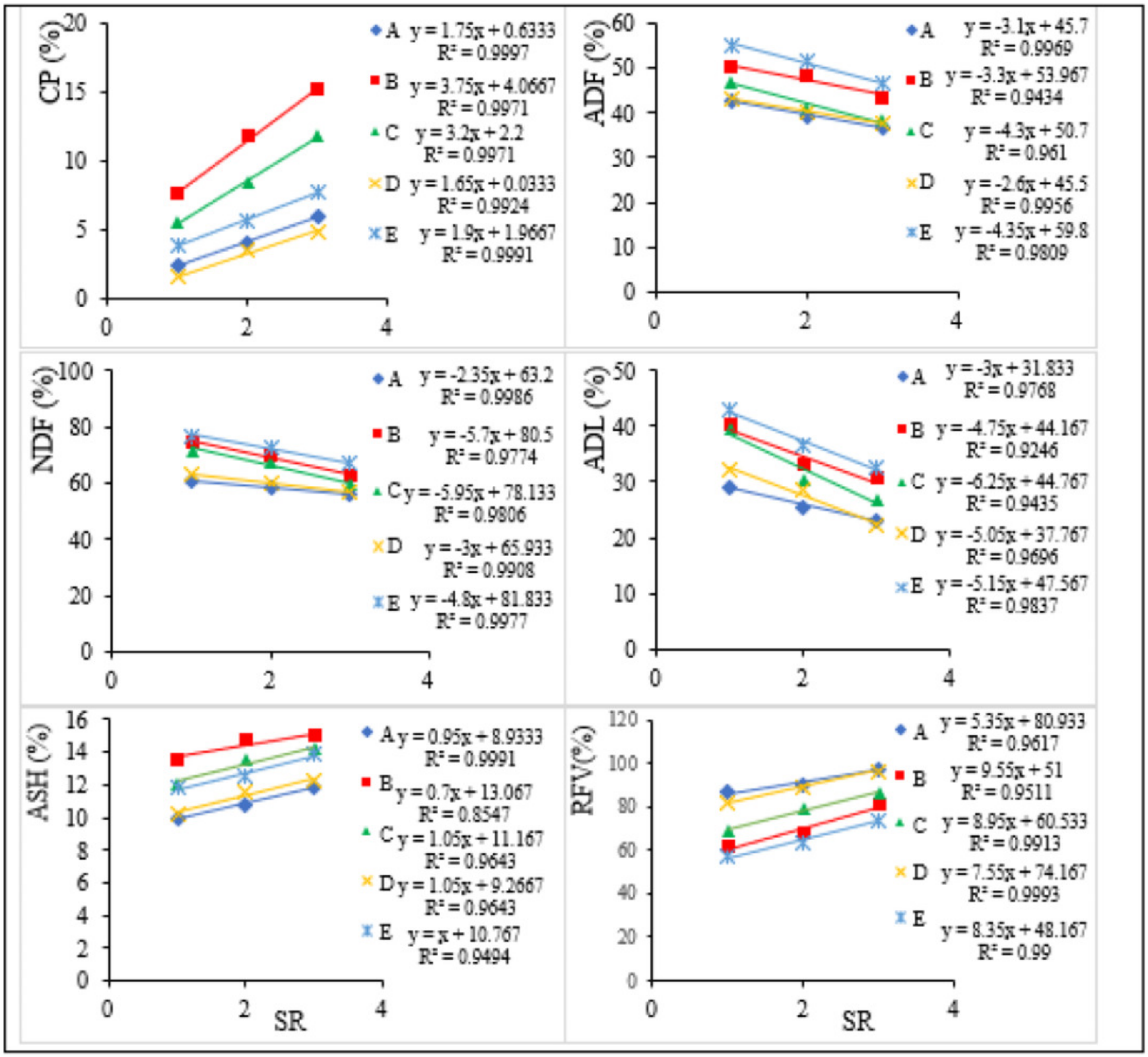

Figure 5

Scree plot: Eigenvalues plotted in descending order (A) and Principal Components in a two-dimensiotal space (B).

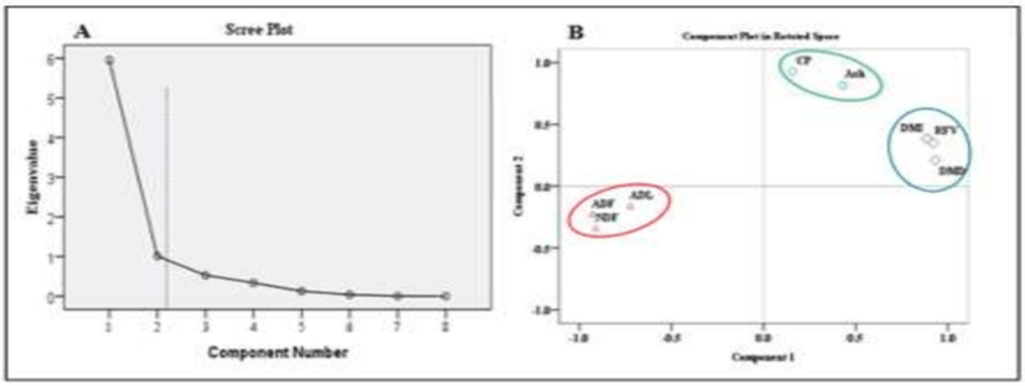

Figure 6

The mean forage nutrient concentration (%) at rainy season and dry season under different grazing intensity. Error bars indicate standard error.

Ds = dry season, **Rs** = rainy season, **CP** = crude protein, **ADF** =acid detergent fiber, **NDF** = neutral detergent fiber, **ADL** = acid detergent lignin, **DMD** = dry matter digestibility, **DMI**= dry matter intake **RFV** = relative feed/forage value.

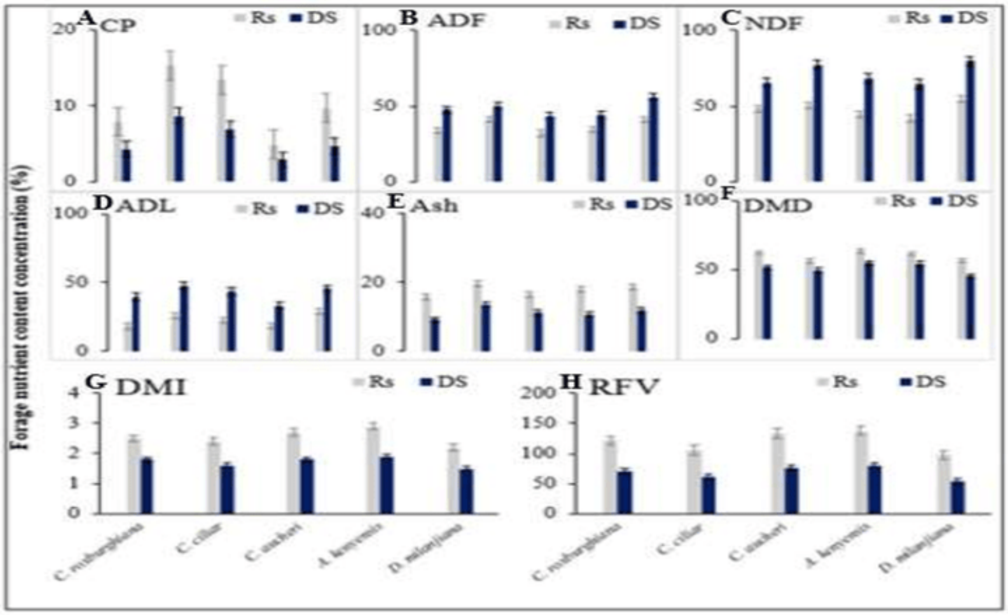
A CP
B ADF
C NDF
D ADL
E Ash
F DMD
G DMI
H RFV
Rs
DS
Forage nutrient content concentration (%)
C. roxburghiana
C. ciliar
C. stuckeri
A. kenyensis
D. milanjiana

Table 1(on next page)

Standard procedures and methods used to analyses forage nutritive value

DMD = dry matter digestibility, DMI= dry matter intake.

TABLE 1 Standard procedures and methods used to analyses forage nutritive value

Major forage nutrition compositions	Analyses procedures and methods used	Reference
Crude protein (CP)	AOAC (1995)	Zhai *et al.,* (2018)
Acid detergent fiber (ADF)	Acid detergent solution	Van Soest, Robertson & Lewis, (2015)
Neutral detergent fiber (NDF)	Neutral washing liquid	Van Soest *et al.,* (2015)
Acid detergent lignin (ADL)	ANKOM 200 Fiber Analyzed	Van Soest *et al.,* (2015)
Ash contents	AOAC (1990)	Zhai *et al.,* (2018)
Relative feed/forage value (RFV)	RFV= (%DMD x %DMI) ÷ 1.29 Where 1.29 = the expected digestible dry matter intake as % of body weight; DMD = 88.9 - (ADF% × 0.779), DMI = 120/% NDF.	Newman *et al.,* (2009); Schacht, Volesky, Stephenson, Klopfenstein & Adams (2010)

DMD = dry matter digestibility, DMI= dry matter intake.

Table 2(on next page)

Effects of grazing intensity on forage nutritive value of each grass species

Values in columns with different lower-case letters (a, b--etc) are significantly different ($p<0.05$) and values with the same second double lower-case letters under some treatment (aa, ba, cc, bc—etc) and values with both lower case and upper-case letters across the treatment (aB, -- etc) are indicated not significant difference ($p> 0.05$). GI = grazing intensity, NG = non- grazing, MG = moderate grazing, OG = over grazing, CP = crude protein, ADF =acid detergent fiber, NDF = neutral detergent fiber, ADL = acid detergent lignin, DMD = dry matter digestibility, DMI= dry matter intake RFV = relative feed/forage value.

TABLE 2 Effects of grazing intensity on forage nutritive value of each grass species

GI	Grass species	Forage nutrient compositions (%)							
		CP	ADF	NDF	ADL	Ash	DMD	DMI	RFV
NG	*C. roxburghiana*	2.4^{a}	42.7^{aB}	60.8^{aB}	29.1^{aA}	9.9^{aaA}	56.1^{a}	2.0^{aaA}	86.9^{aA}
	C. ciliar	7.7^{bE}	50.2^{b}	74.3^{b}	40.2^{b}	13.6^{bB}	49.8^{b}	1.6^{bbB}	61.8^{b}
	C. aucheri	5.5^{cC}	46.9^{cA}	71.7^{c}	39.4^{b}	12.1^{cC}	52.4^{cA}	1.7^{dbB}	69.0^{c}
	A. kenyensis	1.6^{d}	43.0^{d}	63.1^{dC}	32.2^{cB}	10.2^{daA}	55.4^{aB}	1.9^{caC}	81.6^{d}
	D. milanjiana	3.9^{e}	55.1^{e}	76.9^{e}	42.8^{d}	11.9^{cC}	46.0^{e}	1.6^{bbB}	57.0^{e}
MG	*C. roxburghiana*	4.1^{cc}	39.3^{c}	58.6^{c}	25.3^{c}	10.8^{cA}	58.3^{cC}	2.0^{aaA}	90.4^{c}
	C. ciliari	11.8^{dD}	48.3^{d}	70.1^{d}	33.1^{d}	14.8^{d}	51.3^{d}	1.7^{bbB}	67.6^{d}
	C. aucheri	8.4^{e}	41.1^{ee}	67.2^{eA}	30.5^{e}	13.5^{bB}	56.9^{e}	1.8^{dC}	79.4^{e}
	A. kenyensis	3.5^{c}	40.1^{ee}	59.6^{c}	28.7^{bA}	11.6^{bbC}	61.6^{b}	2.0^{caA}	89.5^{b}
	D. milanjiana	5.7^{bA}	51.8^{b}	72.5^{b}	36.5^{a}	12.5^{abC}	48.5^{a}	1.7^{dbB}	63.9^{a}
OG	*C. roxburghiana*	5.9^{eA}	36.5^{e}	56.1^{e}	23.1^{e}	11.8^{b}	60.0^{e}	2.1^{aa}	97.6^{eb}
	C. ciliari	15.2^{c}	43.6^{aB}	62.9^{cC}	30.7^{c}	15.0^{a}	54.9^{aB}	1.9^{ebC}	80.9^{c}
	C. aucheri	11.9^{dD}	38.3^{dd}	59.8^{bB}	26.9^{d}	14.2^{d}	59.0^{ddC}	1.9^{bbC}	86.9^{dA}
	A. kenyensis	4.9^{bcC}	37.8^{cd}	57.1^{e}	22.1^{a}	12.3^{bC}	59.4^{cdC}	2.1^{ba}	96.7^{ab}
	D. milanjiana	7.7^{aE}	46.4^{aA}	67.3^{aA}	32.5^{bB}	13.9^{eB}	52.8^{bA}	1.8^{dbC}	73.7^{b}

Note. Values in columns with different lower-case letters (a, b--etc) are significantly different ($p<0.05$) and values with the same second double lower-case letters under some treatment (aa, ba, cc, bc—etc) and values with both lower case and upper-case letters across the treatment (aB, -- etc) are indicated not significant difference ($p> 0.05$). GI = grazing intensity, NG = non-grazing, MG = moderate grazing, OG = over grazing, CP = crude protein, ADF =acid detergent fiber, NDF = neutral detergent fiber, ADL = acid detergent lignin, DMD = dry matter digestibility, DMI= dry matter intake RFV = relative feed/forage value.

Table 3 (on next page)

Interaction effects of seasonal variation and GI on forage nutritive value of each grass species

Values in columns with different lower-case letters (a, b--etc) are significantly different ($p<0.05$) and values with the some second double lower case letters under the some treatment (aa, ba, cc, bc—etc) and values with both lower case and upper case letters across the treatment (aB, abA, acBD-- etc) are indicated not significant difference ($p > 0.05$). GI = grazing intensity, Ds = dry season, Rs = rainy season, NG = non- grazing, MG = moderate grazing, OG = over grazing, CP = crude protein, ADF =acid detergent fiber, NDF = neutral detergent fiber, ADL = acid detergent lignin, DMD = dry matter digestibility, DMI= dry matter intake RFV = relative feed/forage value.

TABLE 3 Interaction effects of seasonal variation and GI on forage nutritive value of each grass species

Treatment	Grass species	Forage nutrient compositions (%)							
		CP	ADF	NDF	ADL	Ash	DMD	DMI	RFV
Rs X NG	*C. roxburghiana*	5.9^{ab}	38.1^{aaB}	53.2^{aA}	21.5^{aA}	14.1^{aa}	59.2^{aaA}	2.3^{aaA}	106^{a}
	C. ciliar	10.9^{bE}	44.7^{b}	56.3^{b}	30.8^{b}	17.7^{bA}	54.1^{b}	2.1^{bdB}	88^{b}
	C. aucheri	10.6^{cC}	34.9^{cA}	50.4^{cB}	28.8^{bB}	13.5^{ca}	61.7^{cB}	2.4^{aaA}	115^{caA}
	A. kenyensis	2.9^{d}	37.4^{daE}	47.2^{dC}	23.2^{c}	15.7^{dbB}	59.8^{aaA}	2.5^{aaC}	116^{daA}
	D. milanjiana	7.8^{ebC}	47.1^{e}	60.0^{e}	33.7^{d}	16.4^{cbB}	52.2^{e}	2.0^{bdB}	81^{e}
Rs X MG	*C. roxburghiana*	7.8^{cC}	34.3^{ceA}	48.1^{cC}	17.9^{c}	15.8^{ccB}	62.2^{cbB}	2.5^{baC}	121^{cB}
	C. ciliari	16.1^{dD}	41.3^{db}	50.5^{dB}	25.1^{d}	19.9^{dC}	56.7^{dc}	2.4^{baA}	105^{d}
	C. aucheri	12.8^{eE}	31.8^{e}	45.3^{eA}	21.2^{eaA}	16.5^{bcB}	64.1^{e}	2.6^{baC}	129^{e}
	A. kenyensis	4.8^{c}	35.1^{ee}	41.9^{c}	19.6^{baA}	18.0^{bdD}	61.6^{bbB}	2.9^{cE}	138^{bC}
	D. milanjiana	10.2^{bA}	41.2^{bb}	54.1^{bA}	29.1^{aB}	17.5^{adA}	56.8^{ac}	2.2^{eB}	97^{a}
Rs X OG	*C. roxburghiana*	9.9^{eE}	29.5^{e}	43.9^{e}	14.7^{e}	17.3^{bAD}	65.9^{ee}	2.7^{eeE}	138^{eC}
	C. ciliari	18.9^{c}	38.2^{aB}	45.2^{cC}	21.3^{cA}	21.2^{afe}	59.1^{aA}	2.7^{deE}	124^{cB}
	C. aucheri	16.7^{dD}	30.0^{d}	38.8^{b}	18.1^{d}	19.2^{df}	65.5^{de}	3.1^{cb}	157^{db}
	A. kenyensis	6.9^{bcC}	31.9^{c}	37.1^{e}	13.1^{a}	20.3^{beC}	64.0^{c}	3.2^{db}	159^{ab}
	D. milanjiana	11.2^{aE}	34.6^{aA}	49.9^{aB}	24.5^{b}	21.9^{ee}	61.9^{bB}	2.4^{aA}	115^{bA}
Ds X NG	*C. roxburghiana*	2.2^{a}	55.2^{aa}	72.8^{aA}	49.9^{a}	8.1^{aa}	45.9^{aa}	1.6^{aaA}	56.9^{a}
	C. ciliari	6.6^{bB}	54.4^{ba}	88.5^{bb}	53.1^{e}	12.0^{bA}	46.5^{ba}	1.4^{bb}	50.5^{b}
	C. aucheri,	4.4^{cC}	49.7^{cA}	77.0^{cB}	51.2^{bb}	9.1^{cB}	50.2^{cA}	1.6^{daA}	62.3^{cA}
	A. kenyensis	1.3^{d}	48.0^{d}	69.3^{dC}	39.4^{cA}	8.9^{daB}	51.5^{a}	1.7^{caA}	67.9^{d}
	D. milanjiana	3.5^{eDC}	59.9^{e}	87.9^{eb}	51.6d^{b}	10.4^{c}	42.2^{e}	1.4^{bb}	45.8^{e}
Ds X MG	*C. roxburghiana*	3.9^{cC}	49.3^{ccA}	64.6^{c}	38.6^{cA}	9.3^{cB}	50.3^{cbA}	1.9^{acB}	74.1^{ca}
	C. ciliari	8..2^{dD}	49.9^{dcA}	77.1^{dB}	48.0^{d}	14.8^{d}	50.0^{dbA}	1.6^{beA}	62.0^{dA}
	C. aucheri	7.2^{e}	41.8^{ee}	68.8^{eC}	41.8^{eB}	11.2^{bbA}	56.3^{e}	1.7^{dA}	74.2^{ea}
	A. kenyensis	3.1^{cD}	44.2^{ee}	63.7^{c}	33.7^{b}	11.3^{bbA}	54.5^{b}	1.9^{ccB}	80.3^{b}
	D. milanjiana	5.0^{bA}	56.8^{b}	79.1^{b}	47.9^{a}	11.7^{abA}	44.7^{a}	1.5^{deA}	52.0^{a}
Ds X OG	*C. roxburghiana*	6.8^{eB}	38.7^{ee}	59.3^{ee}	29.7^{e}	9.9^{bB}	58.8^{ee}	2.0^{adB}	91.2^{eb}
	C. ciliari	11.4^{c}	46.5^{aB}	66.6^{c}	42.8^{cB}	14.0^{a}	52.7^{a}	1.8^{ecB}	73.5^{c}
	C. aucheri	9.1^{dD}	39.4^{dde}	59.4^{be}	37.4^{dc}	13.1^{d}	58.2^{de}	2.0^{bdB}	90.2^{db}
	A. kenyensis	4.4^{bC}	40.3^{cd}	61.1^{e}	26.6^{a}	11.9^{bA}	57.5^{c}	2.0^{bdB}	89.1^{a}
	D. milanjiana	5.7^{aA}	51.4^{a}	72.3^{aA}	37.3^{bc}	13.3^{e}	48.9^{b}	1.7^{dcA}	64.4^{b}

Note. Values in columns with different lower-case letters (a, b--etc) are significantly different ($p<0.05$) and values with the some second double lower case letters under the some treatment (aa, ba, cc, bc—etc) and values with both lower case and upper case letters across the treatment (aB, abA, acBD-- etc) are indicated not significant difference ($p > 0.05$). GI = grazing intensity, Ds = dry season, Rs = rainy season, NG = non- grazing, MG = moderate grazing, OG = over grazing, CP = crude protein, ADF =acid detergent fiber, NDF = neutral detergent fiber, ADL = acid detergent lignin, DMD = dry matter digestibility, DMI= dry matter intake RFV = relative feed/forage value.

Table 4(on next page)

Spearman’s correlation coefficients of forage nutrient contents in the rainy and dry seasons at different GI

Rs = rainy season, Ds = dry season.

TABLE 4 Spearman's correlation coefficients of forage nutrient contents in the rainy and dry seasons at different GI

	RS								Ds							
	CP	ADF	NDF	ADL	Ash	DMD	DMI	RFV	CP	ADF	NDF	ADL	Ash	DMD	DMI	RFV
CP	1.00	-.41	-.46	-.28	.70	.39	.45	.45	1.00	-.37	-.27	.04	.35	.37	.28	.34
ADF		1.00	.92	.61	-.54	-.99	-.86	-.92		1.00	.87	.01	-.16	-1.0	-.88	-.96
NDF			1.00	.64	-.67	-.91	-.96	-.97			1.00	.04	.01	-.87	-.98	-.95
ADL				1.00	-.46	-.60	-.67	-.68				1.00	.07	-.01	-.13	-.11
Ash					1.00	.53	.72	.69					1.00	.16	.06	.11
DMD						1.00	.85	.91						1.00	.88	.96
DMI							1.00	.99							1.00	.97
RFV								1.00								1.00

Note. Rs = rainy season, Ds = dry season.

Table 5 (on next page)

Spearman's correlation coefficients of forage nutrient contents at different GI

NG = non-grazing, MG = moderately grazing, OG = over grazing

TABLE 5 Spearman's correlation coefficients of forage nutrient contents at different GI

	NG								MG							
	CP	ADF	NDF	ADL	Ash	DMD	DMI	RFV	CP	ADF	NDF	ADL	Ash	DMD	DMI	RFV
CP	1.00	.52	.72	.70	.96	-.53	-.78	-.70	1.00	.44	.66	.46	.96	-.53	-.76	-.63
ADF		1.00	.94	.92	.69	-.99	-.90	-.96		1.00	.90	.94	.52	-.95	-.87	-.95
NDF			1.00	.99	.86	-.95	-.99	-.99			1.00	.95	.75	-.91	-.99	-.98
ADL				1.00	.84	-.93	-.98	-.99				1.00	.61	-.86	-.90	-.95
Ash					1.00	-.70	-.91	-.85					1.00	-.55	-.82	-.71
DMD						1.00	.91	-.96						1.00	.91	.96
DMI							1.00	.99							1.00	.97
RFV								1.00								1.00

	OG							
	CP	ADF	NDF	ADL	Ash	DMD	DMI	RFV
CP	1.00	.39	.40	.60	.91	-.38	-.58	-.53
ADF		1.00	.98	.94	.68	-.99	-.85	-.94
NDF			1.00	.96	.71	-.97	-.93	-.99
ADL				1.00	.83	-.94	-.95	-.99
Ash					1.00	-.66	-.84	-.80
DMD						1.00	.84	.95
DMI							1.00	.97
RFV								1.00

Note. NG = non-grazing,
MG = moderately grazing,
OG = over grazing

Table 6(on next page)

Rotated component matrix for nutritional components of forage species data (Extraction method: Principal Component Analysis. Rotation method: Varimax with Kaiser Normalization)

TABLE 6 Rotated component matrix for nutritional components of forage species data (Extraction method: Principal Component Analysis. Rotation method: Varimax with Kaiser Normalization)

Total Variance Explained						
Component	Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.954	74.427	74.427	4.925	61.564	61.564
2	1.011	12.641	87.067	2.040	25.503	87.067